ARJUNA

JEE

LECTURE - 06

Atomic structure

Sarvesh sir

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Q. The radius of the second Bohr orbit for hydrogen atom is (Planck's constant (h) = 66262 × 10^{-34}) Js: mass of electron = 9.1091 × 10^{-31} kg : charge of electrons (e) = 1.60210 × 10^{-19} C : permittivity of vacuum (ϵ_0) = 8.854185 × 10^{-12} kg^{-1} m^{-3} A^2) **[2017 Main]**

A 1.65 Å

B 4.76 Å

C 0.529 Å

D 2.12 Å

3

$$r_n = 0.529 \times \frac{n^2}{Z} A^0$$

$n = 2$

$Z = 1$

$$r_2 = 0.529 \times \frac{4}{1}$$

$$= 2.116 A^0 \simeq 2.12 A^0$$

$C_{SP} = 10$ x

$$\Rightarrow r_n = 0.529 \times \frac{n^2}{Z} \text{ Å}$$

→ $r_n \propto n^2$

→ $r_n \propto \frac{1}{Z}$

* yadi orbit ka number na diya jaye Question me to humne $n=1$ suppose

Case-1 Relation b/w Radius of two different orbit in same Atom

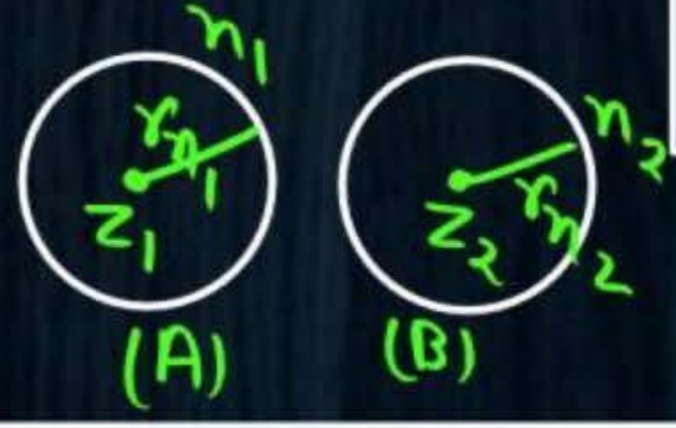
$$\frac{r_{n_1}}{r_{n_2}} = \frac{n_1^2}{n_2^2}$$

or $r_{n_1} : r_{n_2} = n_1^2 : n_2^2$

Case-2 → find out ratio of radius of n_1, n_2, n_3 --- orbits

$r_{n_1} : r_{n_2} : r_{n_3} \rightarrow n_1^2 : n_2^2 : n_3^2$ ---

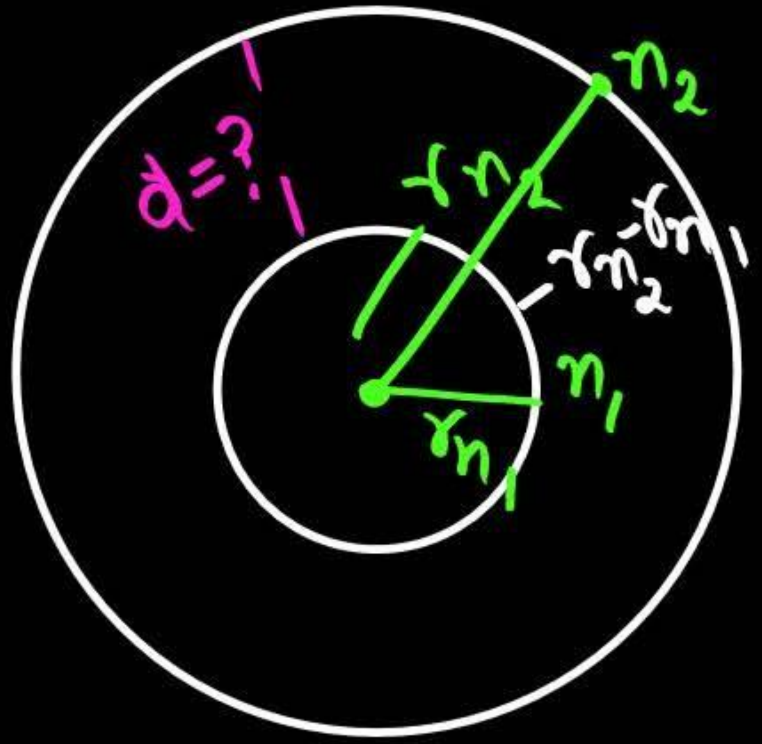
Case-3 → Compare in two different species.



$$\frac{r_{n_1}}{r_{n_2}} = \left(\frac{n_1}{n_2}\right)^2 \left(\frac{Z_2}{Z_1}\right)$$

$C_{SD} = 11$

① * distance between orbit No. of n_2 or energy level (n_2) to orbits No. (n_1)

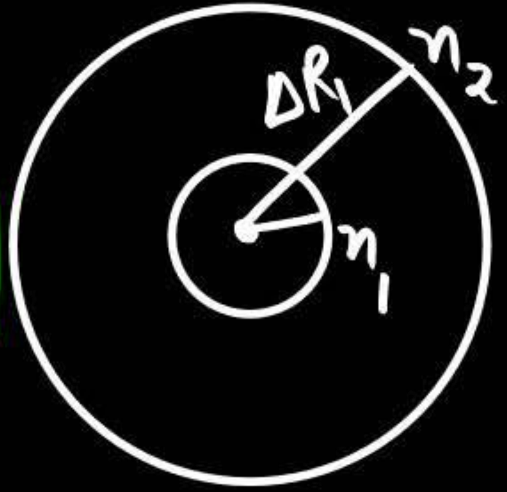


$$(d) = r_{n_2} - r_{n_1} = \frac{0.529}{Z}\left[n_2^2 - n_1^2\right]$$

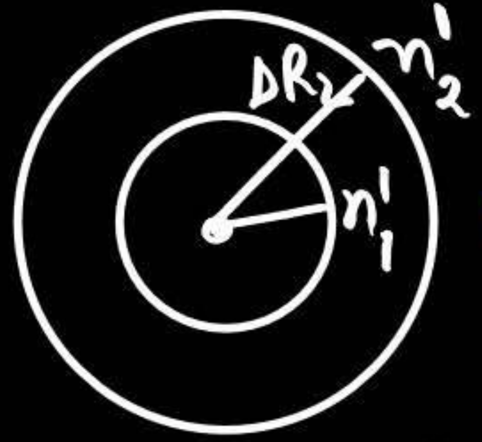
$n_2 > n_1$

②

$$\Delta R_1 = \frac{0.529}{Z_1}\left[n_2^2 - n_1^2\right]$$



(A)



(B)

$$\Delta R_2 = \frac{0.529}{Z_2}\left[(n_2')^2 - (n_1')^2\right]$$

$$\frac{\Delta R_1}{\Delta R_2} = ?$$

Q Calculate the distance between 5th bohr's orbital of H-atom and 3rd bohr's orbital of H-atom.

(a) 7

(b) 12

(c) 16

✓ (d) None of these

$$\Delta R = \frac{0.529}{Z}\left(n_2^2 - n_1^2\right)$$

$$= \frac{0.529}{1}\left(5^2 - 3^2\right)$$

$$= 0.529 \times (25 - 9)$$

$$= 0.529 \times 16 = \underline{\underline{8.464}}\ \text{A}^\circ$$

Q. The radius of hydrogen atom in the ground state is 0.53Å. The radius of Li^{2+} ion (at. No. = 3) in a similar state is:

A 0.17 Å

B 0.53 Å

C 0.265 Å

D 1.06 Å

Home work

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Q. The ratio of radii of first orbits of H, He^{+} and Li^{2+} is

A $1:2:3$

B $6:3:2$

C $1:4:9$

D $9:4:1$

Home work

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Q. Which hydrogen like species will have same radius as that as that of Bohr orbit of hydrogen atom? → $r_{a_0} = 0.529\ A^\circ$ $\left(r_n = 0.529 \times \left(\frac{n^2}{Z}\right)\right)$

$Z=1, n=1$

[2004 M]

A ✗ n = 2, Li^{2+} $\frac{4}{3}$

B ✓ n = 2, Be^{3+} → $\frac{4}{4} = 1$

C ✗ n = 2, He^{+} $= \frac{4}{2}$

D ✗ n = 3, Li^{2+} → $\frac{9}{3}$

$$r_n = 0.529 \times \left(\frac{n^2}{Z}\right)$$

↓

(1)

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Q. The difference between the radii of 3^{rd} and 4^{th} orbits of Li^{2+} is ΔR_1. The difference between the radii of 3^{rd} and 4^{th} orbits of He^+ is ΔR_2. Ratio $\Delta R_1 : \Delta R_2$ is ______.

[2020 Main, 5 Sep. I]

2 minutes = 120 sec

A 8 : 3

B 3 : 8

C 2 : 3 ✓

D 3 : 2

$Li = Z = 3$

$\Delta R_1 = \frac{0.529}{3}[16-9]$ — (I)

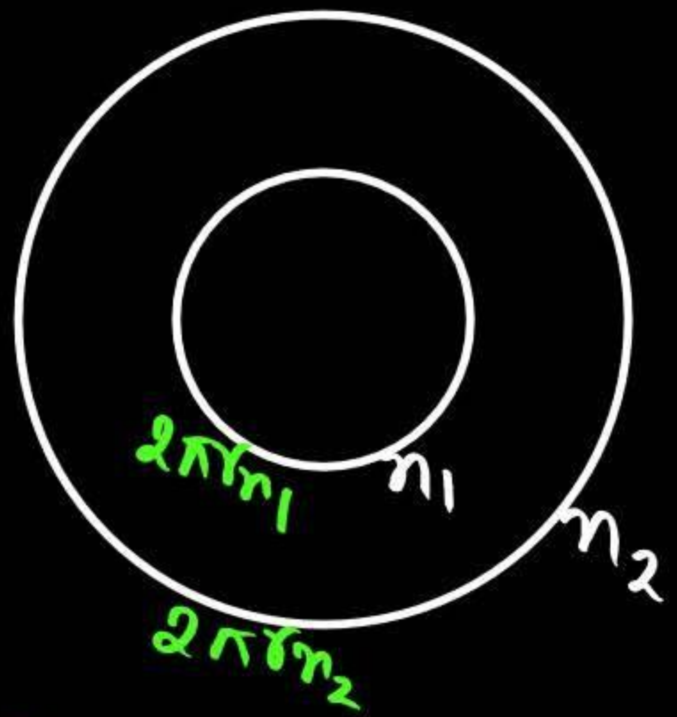
$He^+ \rightarrow Z = 2$

$\Delta R_2 = \frac{0.529}{2}[16-9]$ — (II)

$\frac{\Delta R_1}{\Delta R_2} = \frac{2}{3}$

$C_{SD} = 12$

* findout ratio of circumference of n_1 energy level and n_2 energy level



$$\frac{C_{n_1}}{C_{n_2}} = \frac{r_{n_1}}{r_{n_2}} = \frac{n_1^2}{n_2^2}$$

$$\text{Circumference} = 2\pi r_{n_1}$$

$$= 2\pi r_{n_2}$$

Q Calculate ratio of Circumference of 3^{rd} and 4^{th} bohr's radius of He^+ ion.

(a) $\frac{3}{4}$

(b) ✓ $\frac{9}{16}$

(c) 3×4

(d) None of these

40 sec

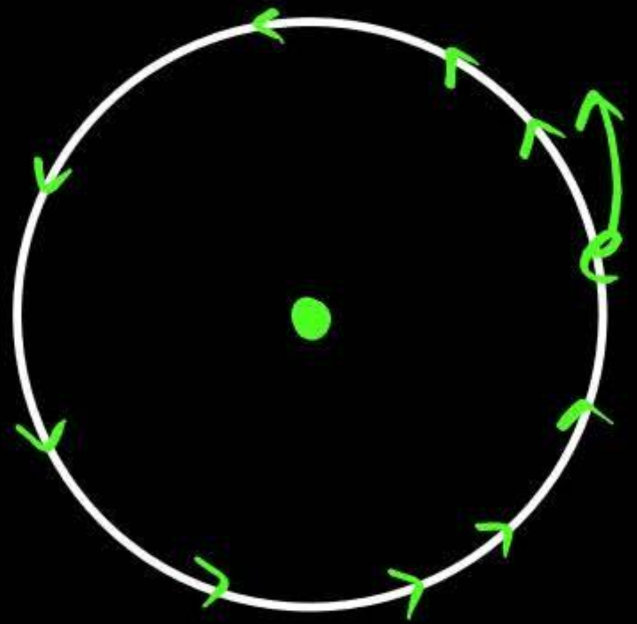
$$\frac{C_3}{C_4} = \frac{r_3}{r_4} = \frac{n_1^2}{n_2^2} = \frac{(3)^2}{(4)^2} = \frac{9}{16}$$

$$r_3 = 0.529 \times \frac{(3)^2}{Z}$$

$$r_4 = 0.529 \times \frac{(4)^2}{Z}$$

$$\frac{r_3}{r_4} = \frac{(3)^2}{(4)^2} = \frac{9}{16}$$

Total energy of revolving electron

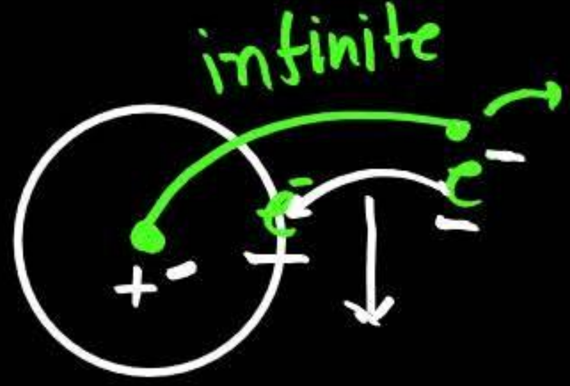


total Energy = Potential energy + Kinetic energy

$$P.E = -\frac{KZe^2}{r}$$

$$K.E = \frac{1}{2}mu^2 = +\frac{KZe^2}{2r}$$

Suppose → infinite distance of nucleons



P.E = 0
suppose

$$P.E \text{ of } e^- = -\frac{Kq_1q_2}{r} = -\frac{Ke \times Ze}{r}$$

$$P.E = -\frac{KZe^2}{r}$$

some amount of energy consume to move e^- at infinite to n-energy level, so P.E. of e^- is negative

$$T.E = P.E. + K.E.$$

$$= -\frac{KZe^2}{r} + \frac{KZe^2}{2r}$$

$$\boxed{T.E. = -\frac{KZe^2}{2r}}$$

$$\boxed{T.E = -13.6 \times \frac{Z^2}{n^2} \text{ ev/atom}}$$

$$\frac{mu^2}{\cancel{r}} = \frac{Kq_1q_2}{r^{\cancel{2}}}$$

$$mu^2 = \frac{Kq_1q_2}{r}$$

$$\frac{1}{2}mu^2 = \frac{Kq_1q_2}{2r}$$

$$K.E = \frac{Kq_1q_2}{2r}$$

$$\boxed{K.E. = \frac{KZe^2}{2r}}$$

$C_{SD} = 13$

① $T \cdot E = -13.6 \times \frac{Z^2}{\eta^2}$ ev|atom

② per mole $= (T \cdot E.) = -13.6 \times \frac{Z^2}{\eta^2}$ ev $\times N_A$

$1 eV = 1.6 \times 10^{-19}$ Joule

1 Joule $= 1 \times 10^{7}$ erg

③ T·E· of $e^- \rightarrow$ (Joule|mole)-unit

$T \cdot E \cdot = -13.6 \times 1.6 \times 10^{-19} \times 6.022 \times 10^{23} \frac{Z^2}{\eta^2}$ Joule|mole

$= -1.31 \times 10^{6} \frac{Z^2}{\eta^2}$ Jolue|mole

④ $T \cdot E. \propto \frac{1}{\eta^2}$

(5) $T \cdot E \propto Z^2$

Q Calculate total energy of H-atom in ground state.

(a) -13.6 ev/atom ✓

(b) $-13.6 \times \frac{1}{4}$ ev/atom

(c) -1.36 ev/atom

(d) None of these

Sol^n → $n = 1$ (ground state)

$Z = 1$

$$T.E = -13.6 \times \frac{Z^2}{n^2} \text{ ev/atom}$$

$$= -13.6 \frac{(1)^2}{(1)^2} \text{ ev/atom}$$

$$T.E. = -13.6 \text{ ev/atom}$$

$C_{SD} = 14$ → possible total energy of e^- for H-atom $= \frac{-13.6}{n^2}$ ev/atom

$$T.E = -13.6 \times \frac{Z^2}{n^2} \text{ ev/atom}$$

$n = 1, 2, 3, \ldots$

H-atom

$n = 1 \rightarrow T.E. = -13.6 \times \frac{1}{(1)^1} = -13.6$ ev/atom

$n = 2 \rightarrow T.E. = -13.6 \times \frac{1}{(2)^2} = -3.4$ ev/atom

Q → select Correct possible total energy of revolving e^- for H-atom

(a) 8.6 ev (b) 6.4 ev (c) −3.4 ev ✓ (d) −13.6 ev ✓

Q. Which of the following is the energy of a possible excited state of hydrogen ?

JEE-MAINS

A) + 13.6 eV ✗

B) – 6.8 eV ✗

C) – 3.4 eV ✓

D) + 6.8 eV ✗

possible energy = $-\frac{13.6}{n^2}$ eV/atom

$n=1 \rightarrow -13.6$ eV/atom

$n=2 \rightarrow -3.4$ eV/atom

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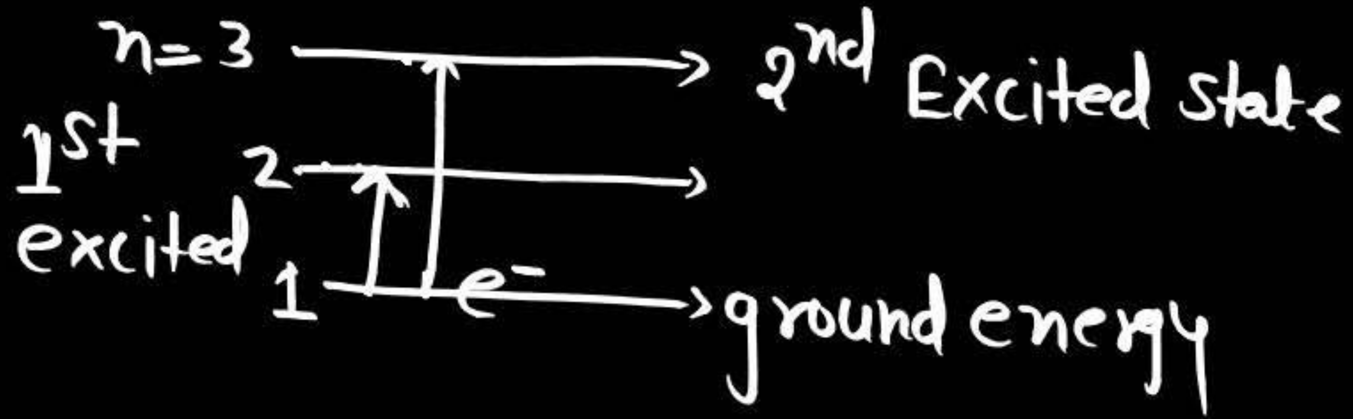
$C_{SD} = 15$

① ground state → $n = 1$

② x^{th} excited state ⇒ $\boxed{n = x+1}$

Q → e^- present 2^{nd} excited state of H-atom



Q Calculate total energy of 2nd excited state of He^+-ion

(a) $-13.6 \times \frac{4}{9}$ ev/atom

(b) $-13.6 \times$ ev/atom

(c) $-13.6 \times \frac{1}{9}$ ev/atom

(d) None of these

Solⁿ → $n = x + 1 = 2 + 1 = 3$

$Z = He^+ = 2$

$T.E. = -13.6 \times \frac{Z^2}{n^2}$ ev/atom

$= -13.6 \times \frac{2^2}{3^2}$

$= -13.6 \times \frac{4}{9}$ ev/atom

$C_{SD} = 16$

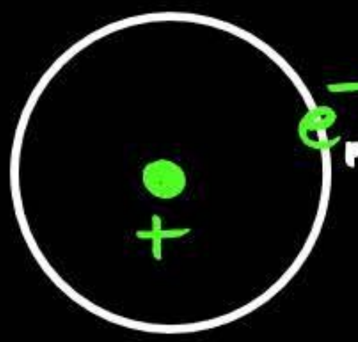
$T.E. = -13.6 \times \frac{Z^2}{n^2}$ eV/atom

→ $P.E. = 2 \times T.E.$

→ $K.E. = |T.E.|$

→ $P.E. = -2 \times K.E.$

Ionisation of n^{th} energy level e^-



$= -13.6 \times \frac{Z^2}{n^2}$ eV/atom

total minimum required energy to remove revolving $\bar{e}$ in n^{th} orbital.

Ionisation energy $= |T.E.$ of n^{th} orbit$|$

$= +13.6 \times \frac{Z^2}{n^2}$ eV/atom

Q. The ionization potential of hydrogen atom is 13.6 eV. The energy required to remove an electron from the n = 2 state of hydrogen atom is

A 27.2 eV

B 13.6 eV

C 6.8 eV

D 3.4 eV

Ionisation energy = | T.E. of 2^{nd} orbital |

$= 13.6 \times \frac{Z^2}{n^2}$ ev/atom

$= 13.6 \times \frac{(1)^2}{4} = +3.4$ ev/atom

Q.

Subjective Questions :

The electron energy in hydrogen atom is given by $E_n = -\frac{21.7\times10^{-12}}{n^2}$ erg.

Calculate the energy required to remove an electron completely from the n = 2 orbit. What is the longest wavelength (in cm) of light that can be used to cause this transition?

IIT-JEE = 1984 (3M)

Ionisation Energy = $|\text{T.E of } 2^{nd} \text{ orbit}|$

$= \frac{21.7\times10^{-12}}{4}$ erg

or

Ionisation Energy $= +\frac{13.6}{4^2}$ ev/atom

$= +3.4$ ev/atom

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$$\frac{hc}{\lambda} = \Delta E =$$

$$\frac{hc}{\lambda} = \frac{21.7 \times 10^{-12}}{4} erg = \frac{21.7 \times 10^{-12} \times 10^{-7}}{4} Joule$$

$$\frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\lambda} = \frac{21.7 \times 10^{-19}}{4}$$

$$\lambda = ?$$

Home work

DPP 04

Thank - You

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